Claims

1.   Method for the edge-machining of an optical lens (L), namely a plastic spectacle lens rotatable with a controlled angle of rotation (φ_B) about a rotational axis of a workpiece (B) with the following steps:

preliminary machining of the edge (R) of the lens (L) by means of at least one combination tool (10) adjustable at least radially relative to the rotational axis of the workpiece (B) and rotatable about a rotational axis of a tool (C) whereby, seen in plan view, the lens (L) is given a circumferential contour (U) that corresponds to a circumferential contour of a holder for the lens (L) apart from a slight degree of oversizing if necessary and

finish-machining of the edge (R) of the lens (L) by means of the combination tool (10) whereby the edge (R) of the lens (L) is provided, when viewed in cross section, with a prespecified edge geometry corresponding to its intended means of fastening to the holder, optionally with a protective chamfer (F_1, F_2) at the transition to one or both optically effective surfaces (O_1, O_2) and optionally polished;

characterised in that the preliminary machining of the edge (R) and the finish-machining of the edge (R) is performed by means of a combination tool (10) comprising both milling cutters (26, 28, 66, 68, 70, 72, 74) and at least one turning tool (36) with said combination tool being rotated at a controlled rotational speed (n_c) about the rotational axis of the tool (C) during a milling machining of the edge (R), and being swivelled with a controlled angle of rotation (φ_C) about the rotational axis of the tool (C) before and optionally also during the turning machining of the edge (R).

2.   Method according to claim 1, characterised in that, before the turning machining of the edge (R) of the lens (L), the combination tool (10) is swivelled with a controlled angle of rotation (φ_C) about the rotational axis of the tool (C) in such a way that the turning tool (36) optionally with radial adjustment of the combination tool (10) relative to the rotational axis of the workpiece (B), is

subsequently brought into contact with the edge (R) in a prespecified relative position between the turning tool (36) and edge (R) at which the face (60) of the turning tool (36) forms a prespecified angle with a tangent (T) applied to the edge (R) at the point of contact with the turning tool (36).

3.   Method according to claim 2, characterised in that the combination tool (10) suitably radially adjusted relative to the rotational axis of the workpiece (B) during turning machining on the edge (R) of a rotating lens (L) which is to be given a circumferential contour (U) deviating from the circular, is swivelled or tracked about the rotational axis of the tool (C) in dependence on the angle of rotation (φ_B) and on the radius to be created $(r_B (\varphi_B))$ of the lens (L) with a controlled angle of rotation $(\varphi_C = f [\varphi_B, r_B (\varphi_B)])$ in such a way that the prespecified angle between the face (60) of the turning tool (36) and the tangent (T) at the point of contact between the turning tool (36) and edge (R) substantially remains constant.

4.   Method according to any one of the preceding claims, characterised in that the preliminary machining of the edge (R) of the lens (L) is performed by means of the milling cutters (26, 28, 66, 68, 70, 72, 74) of the combination tool (10) (Fig. 7).

5.   Method according to any one of the preceding claims, characterised in that during the finish-machining of the edge (R) of the lens (L), a bevel edge (S) with two flanks (K_1, K_2) is created by means of the milling cutters (26, 28, 66, 68) of the combination tool (10) (Figs. 9, 10) which have terminal chamfers (32, 34) provided therefor whereby first one flank (K_2) of the bevel edge (S) is formed by the chamfers (32) at one end of the milling cutters and then the other flank (K_1) of the bevel edge (S) is formed by the chamfers (34) at the opposite end of the milling cutters.

6.   Method according to any one of claims 1 to 4, characterised in that during the finish-machining of the edge (R) of the lens (L), a bevel edge (S) with two flanks (K_1, K_2) is created by

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means of a turning tool (36) of the combination tool (10) (Fig. 14) for which its turning cutter has a V-shaped recess (50).

7.   Method according to any one of claims 1 to 4, characterised in that during the finish-machining of the edge (R) of the lens (L) a bevel edge (S) with two flanks (K_1, K_2) is created by means of a turning tool (36) of the combination tool (10) (Figs. 15, 16) for which its turning cutter has a chamfer (52, 54) at each end whereby first one flank (K_2) of the bevel edge (S) is formed by the chamfer (52) at one end of the turning cutter and then the other flank (K_1) of the bevel edge (S) is formed by the chamfer (54) at the opposite end of the turning cutter.

8.   Method according to any one of claims 1 to 4, characterised in that during the finish-machining of the edge (R) of the lens (L) a groove (N) is formed on the edge (R) by means of a turning tool (36) of the combination tool (10) (Fig. 19) whose turning cutter has a width (b) less than or equal to the width of the groove (N) to be created.

9.   Method according to any one of the preceding claims, characterised in that during the finish-machining of the edge (R) of the lens (L) a protective chamfer (F_1, F_2) is created on the edge (R) at the transition to at least one of the two optically effective surfaces (O_1, O_2) by means of a turning tool (36) of the combination tool (10) whose turning cutter has a chamfer (52, 54) at least at one end or has two adjoining straight cutting areas (56, 58) (Figs. 17, 18) forming a prespecified angle with each other.

10.   Method according to any one of the preceding claims, characterised in that during the finish-machining of the edge (R) of the lens (L), which is comprised of a relatively soft plastic such as polycarbonate, at least one part of the edge (R) is polished by means of a turning tool (36) with

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a negative rake angle (γ) (Fig. 6) and/or whose area (62) of the free surface (64) adjoining the face (60) has a clearance angle (α) equal to zero or approximately zero (Figs. 5, 6).

11.   Method according to any one of the preceding claims, characterised in that the edge (R) of the lens (L) is measured before the preliminary machining of the edge (R) and/or between the preliminary machining and the finish-machining of the edge (R) with regard to radius values ($r_B(\varphi_B)$) and optionally height values ($z_B(\varphi_B)$), and the preliminary machining or finish-machining of the edge (R) is performed taking into account the measured values ($r_B(\varphi_B)$, ($z_B(\varphi_B)$).

12.   Combination tool (10) for the edge-machining of an optical lens (L) namely a plastic spectacle lens, in particular for the performance of the method according to one of the preceding claims, with a base body (20) on which a plurality of milling cutters (26, 28, 66, 68, 70, 72, 74) is provided which, when the combination tool (10) is rotated about a rotational axis of a tool (C), define a cutting circle (38) and by means of which the edge (R) of the lens (L) may in particular be preliminarily machined in such a way that, seen in plan view, the lens (L) is provided with a circumferential contour (U) which corresponds to a circumferential contour of a holder for the lens apart from a slight degree of oversizing if necessary, **characterised in that** on the base body (20) also at least one turning tool (36) is provided which, in the direction of the rotational axis of the tool (C), is arranged axially displaced relative to the milling cutters (26, 28, 66, 68, 70, 72), or is arranged at the axial height of the milling cutters (74) in the circumferential direction of the combination tool (10) between the milling cutters (74) with a turning cutter radially internally offset relative to the cutting circle (38) of the milling cutters (74), whereby the turning tool (36) has a cutter geometry by means of which the lens (L) on the edge (R) may in particular be finish-machined in such a way that viewed in section, according to the intended method of securing it to the holder, the lens (L) on the edge (R) has a prespecified edge geometry and/or is provided with a

protective chamfer (F_1, F_2) at the transition to one or both optically effective surfaces (O_1, O_2) and/or is polished.

13.   Combination tool (10) according to claim 12, characterised in that the turning tool (36) is selected from a group comprising the following turning tools (36):

turning tools (36) whose turning cutter has a width (b) (Fig. 13) that is greater than a maximum edge thickness of the lens (L) which is to be machined or the lens (L) which has been machined thereby,

turning tools (36) whose turning cutter has a V-shaped recess (50) for the formation of a bevel edge (S) on the edge (R) of the lens (L) (Fig. 14),

turning tools (36) whose turning cutter has on at least one end a chamfer (52, 54) for the formation of a flank (K_1, K_2) of a bevel edge (S) on the edge (R) of the lens (L) (Figs. 15, 16) and/or for the creation of a protective chamfer (F_1, F_2) on the edge (R) of the lens (L),

turning tools (36) whose turning cutter has a width (b) that is less than or equal to the width of a groove (N) to be created on the edge (R) of the lens (L) (Fig. 19),

turning tools (36) whose turning cutter has, for the creation of protective chamfers (F_1, F_2) on the edge (R) of the lens (L), two adjoining straight cutting areas (56, 58) forming a prespecified angle with each other (Figs. 17, 18), and

turning tools (36) for polishing the edge (R) of a lens (L) which is comprised of a relatively soft plastic such as polycarbonate, which turning tools (36) have a negative rake angle (γ) (Fig. 6) and/or whose area (62) of the free surface (64) adjoining the face (60) has a clearance angle (α) that is equal to zero or approximately zero (Figs. 5, 6).

14.   Combination tool (10) according to claim 12 or 13, characterised in that provided on the base body (20) are several turning tools (36) which are preferably uniformly distributed over the circumference of the base body (20).

15.   Combination tool (10) according to any one of claims 12 to 14, characterised in that the turning tool (36) is secured detachably to the base body (20).

16.   Combination tool (10) according to any one of claims 12 to 15, characterised in that the milling cutters (26, 28, 66, 68, 70) seen in plan view looking in a direction perpendicular to the rotational axis of the tool (C) are each inclined relative to the rotational axis of the tool (C).

17.   Combination tool (10) according to claim 16, characterised in that in the circumferential direction adjacent milling cutters (70) run in opposite directions inclined relative to the rotational axis of the tool (C) and the opposed inclined milling cutters (70) are arranged alternately on the circumference of the base body (20).

18.   Combination tool (10) according to any one of claims 12 to 17, characterised in that the milling cutters (26, 28, 66, 68) are each provided with a V-shaped recess (30) to form a bevel edge (S) on the edge (R) of the lens (L) whereby the V-shaped recesses (30) of the milling cutters (26, 28, 66, 68) are arranged at the same axial height in the direction of the rotational axis of the tool (C).

19.   Combination tool (10) according to any one of claims 12 to 18, characterised in that the milling cutters (26, 28, 66, 68) are each provided on at least one end with a chamfer (32, 34) for the formation of a flank (K_1, K_2) of a bevel edge (S) on the edge (R) of the lens (L) and/or for the creation of a protective chamfer (F_1, F_2) on the edge (R) of the lens (L) whereby the chamfers (32, 34) of the milling cutters (26, 28, 66, 68) are arranged at the same axial height in the direction of the rotational axis of the tool (C).

20.   Device for the edge-machining of an optical lens (L) namely a plastic spectacle lens in particular for the performance of the method according to any one of claims 1 to 11 using a combination tool (10) in particular according to any one of claims 12 to 19, with two aligned holding shafts (14, 16) rotatable with a controlled angle of rotation (φ_B) about a rotational axis of a workpiece (B) between which the lens (L) may be clamped, and a tool spindle (12) by means of which the combination tool (10) may be driven rotatably about a rotational axis of a tool (C) running substantially parallel to the rotational axis of the workpiece (B) whereby the holding shafts (14, 16) and the tool spindle (12) may be moved with position control towards each other in a first axial direction (X) and optionally parallel to each other in a second axial direction (Z) perpendicular to the first axial direction (X), **characterised in that** for the turning machining of the edge (R) of the lens (L) to be machined, the combination tool (10) may be swivelled with a controlled angle of rotation (φ_C) by means of the tool spindle (12) about the rotational axis of the tool (C) so that a turning tool (36) provided on the combination tool (10) may be brought into a defined turning machining engagement with the edge (R) to be machined.